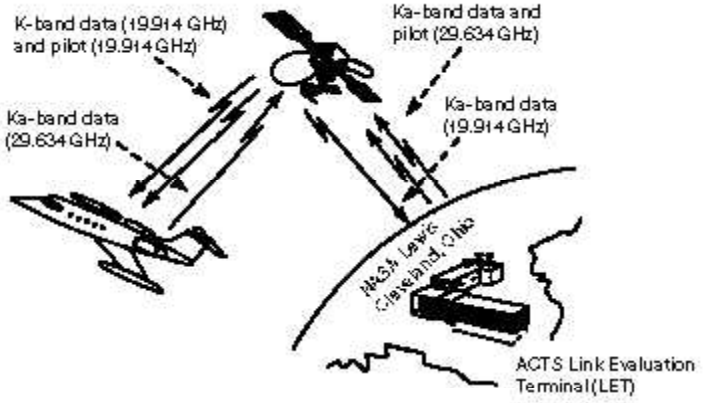
ACTS Aeronautical Terminal Experiment (AERO-X)



System setup.

During the summer of 1994, the performance of an experimental mobile satellite communication system was demonstrated. Using the Advanced Communications Technology Satellite (ACTS) and the ACTS Mobile Terminal (AMT), the system demonstrated an active Monolithic Microwave Integrated Circuit (MMIC) phased-array antenna system. The antenna system was installed onboard one of NASA Lewis Research Center's research aircraft, a Learjet Model 25. It proved the viability of in-flight satellite communications services via small, flush, mountable electronic phased-array antennas. The figure at the top illustrates the overall system setup for the ACTS Aeronautical Terminal Experiment (AERO-X). The Link Evaluation Terminal (LET) at Lewis in Cleveland, Ohio, interfaced with fixed-AMT equipment, providing a seamless connection with the Public Service Telephone Network. As the Learjet was flown over several major cities across the U.S., this demonstration system allowed passengers onboard to make telephone calls as if they were using a cellular system. ACTS was operated in its microwave switch matrix mode with a spot beam for the Learjet and another spot beam dedicated to the LET.

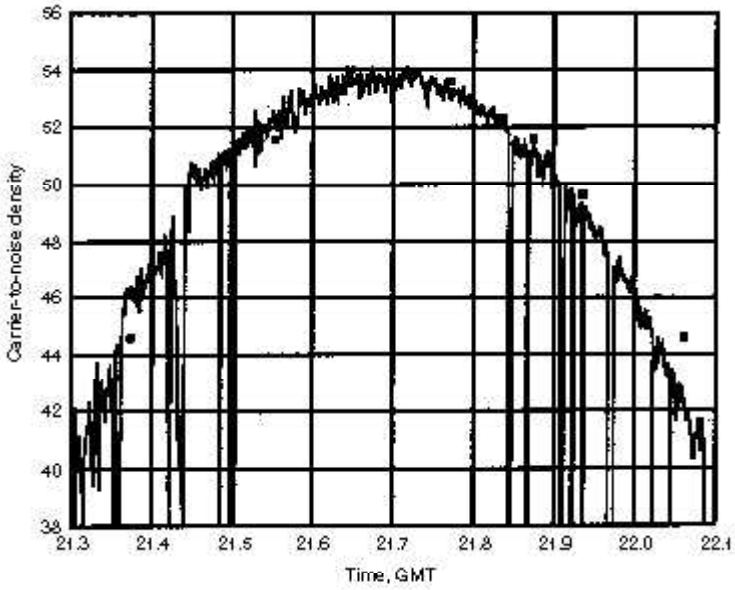
ACTS is a proof-of-concept 30/20-GHz satellite launched by the Space Shuttle Discovery (STS- 51) in September 1993. It has been operating ever since and continues to validate key technologies such as (1) the satellite multibeam antenna, which produces multiple high-gain spot beams that can be rapidly hopped, scanned, or fixed; (2) the baseband processor, which demodulates, routes individual circuit-switched messages, and remodulates; and (3) the microwave switch matrix, which handles up to 9000-MHz bandwidth signals and provides rapidly reconfigurable connectivity between the spot beams. The following figure shows satellite coverage afforded by the ACTS satellite.

ACTS satellite coverage.

The AMT is a mobile terminal designed to demonstrate the viability of speech (at 2.4, 4.8, and 9.6 kilobits per second (kbps)) and data transmission (at 2.4, 4.8, 9.6, and 64 kpbs) in the 30/20-GHz mobile satellite communications environment. The speech codec uses the Government standard LPC-10, the proposed CELP Government standard, and MRELP (Motorola's proprietary algorithm). Its modem implements a simple, but robust, differential phase shift keying (DPSK) scheme with a rate ½ convolutional coding and interleaving.

The MMIC phased-array antenna system (ref. 1) consisted of one transmit array antenna and two receive array antennas. The antennas were mounted inside the Learjet, looking out the standard Plexiglass window. These array antennas incorporated individual GaAs MMIC devices for the individual radiating elements for electronic beam steering and distributed power amplification. An open-loop antenna controller developed by Lewis used information from the global positioning system and aircraft gyroscopes to electronically steer the array beams toward ACTS during flight.

During the demonstration flights, link performance data were recorded with a power meter, a spectrum analyzer, a calibrated 31.8-kHz bandpass filter, and a global positioning system receiver. In the following figure (which shows the inbound carrier-to-noise ratio), the continuous trace is the measured performance and the rectangles represent the predicted performance. The AERO-X program provided an opportunity to showcase many proof-of-concept technologies found in the ACTS satellite, the active phased-array antennas, and the AMT.



Inbound link carrier-to-noise density versus Greenwich Mean Time (GMT).

Reference

1. Raquet, C., et al.: Ka-Band MMIC Arrays for ACTS Aero Terminal Experiment. Presented at the 43rd Congress of the International Astronautical Federation. Aug. 28 to Sept. 5, 1992.